Design and Implementation of an Adjustable Buck Converter Power Supply with 100V AC Input

Abstract — This paper presents the complete design flow of an adjustable buck converter power supply capable of accepting 100V peak-to-peak AC input and providing adjustable DC output from 3.3V to 20V. The design process encompasses simulation in Multisim, schematic capture in Altium Designer, PCB layout, and manufacturing file generation. The system utilizes the LM2596SX-3.3/NOPB buck regulator configured in adjustable mode with a precision potentiometer for output voltage control. Detailed component selection, simulation results, and practical implementation considerations are discussed.

Index Terms — Buck converter, adjustable power supply, AC-DC conversion, PCB design, voltage regulation.

I. INTRODUCTION Modern power electronics require flexible voltage conversion solutions that can accommodate wide input voltage ranges while providing precise output voltage control. This paper documents the development of such a system, beginning with simulation in Multisim, progressing through schematic design in Altium Designer, and culminating in PCB fabrication. The design demonstrates a complete engineering workflow from concept to manufacturable solution.

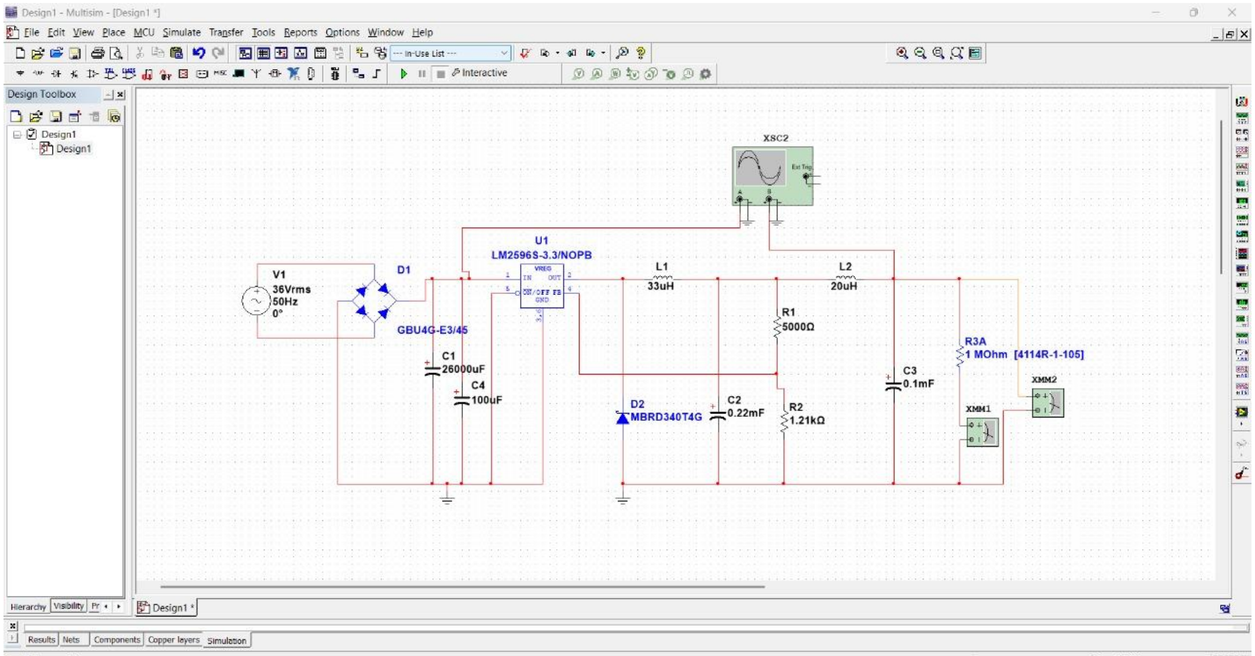
II. DESIGN SPECIFICATIONS The power supply design has the following key specifications:

- **Input Voltage:** 100V peak-to-peak AC (approximately 35Vrms)
- **Output Voltage Range:** 3.3V to 20V adjustable
- **Output Current Capacity:** Up to 3A (limited by LM2596)
- **Output Voltage Control:** Via 5kΩ trimmer potentiometer (R1)
- **Regulation Method:** Buck conversion with voltage-mode PWM
- **Design Tools:** Multisim (simulation), Altium Designer (schematic/PCB)

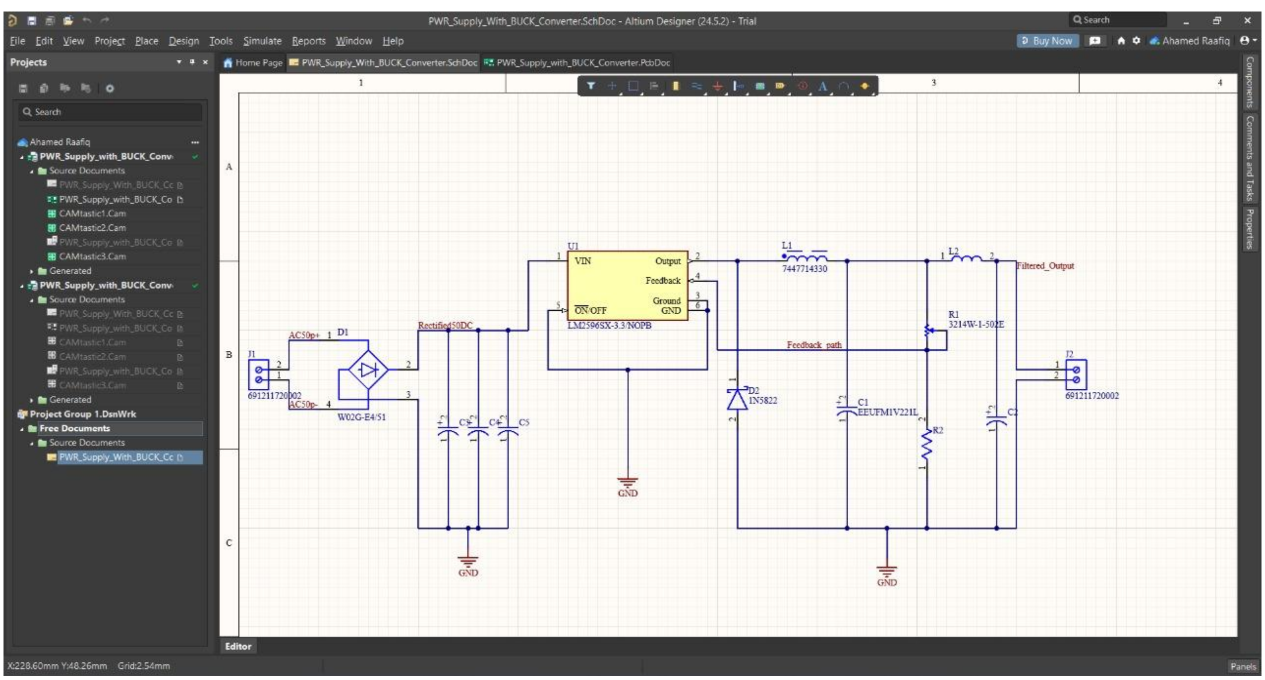
III. DESIGN METHODOLOGY

A. Simulation Phase (Multisim) The design process began with circuit simulation to verify: - Input rectification and filtering behavior - Buck converter stability across the output range - Feedback network response time - Load transient performance - Efficiency estimation

B. Schematic Design (Altium Designer) The simulated design was translated to a formal schematic with: - Proper component symbols - Design rule checking - Netlist generation - BOM compilation



C. PCB Implementation The final design phase included: - Component footprint assignment - Board outline definition - Layer stackup configuration - Routing optimization - Gerber file generation for manufacturing



IV. CIRCUIT ANALYSIS AND COMPONENT SELECTION

A. Input Stage Components

Bridge Rectifier (D1 - W026-E4/51): - 1-phase bridge rectifier for AC-DC conversion - Rated for >100V reverse voltage - Handles input current surges

Input Filter Capacitors (C1–C5): - C1 (EEUFRH1V221L): 220µF/35V aluminum electrolytic - C2, C5 (EEUFRH110): 100µF/35V bulk filtering - C3, C4 (EEUFR10102L): 1000µF/35V for ripple reduction

B. Power Conversion Stage

Regulator IC (U1 - LM2596SX-3.3/NOPB): - 3.3V fixed version used in adjustable configuration - 150kHz switching frequency - Internal current limit (3A) and thermal shutdown

Power Inductor (L1 - 7447714330): - WE-PD series shielded inductor - Selected for 3A current handling - Low core losses at 150kHz

Freewheeling Diode (IN5822): - Schottky diode for efficient reverse current path - 40V reverse voltage rating - Fast recovery characteristics

C. Output Stage

Adjustment Potentiometer (R1 - 3214W-1-502E): - 5kΩ 5-turn trimmer for precise output adjustment - Bourns 3214W series with 1% tolerance - Enables 3.39V to 19.2V output range

Current Sense Resistor (R2 - MCAI2060D5000BP50): - 50mΩ precision current sense resistor - 1206 package for power handling - Used for potential current monitoring

Secondary Inductor (L2 - IHLP2552CZER220M11): - IHLP series high-current inductor - 220nH value for additional output filtering - Low DCR for minimal voltage drop

D. Connectors (J1, J2 - 691211720002): - Terminal blocks for secure input/output connections - Rated for high-voltage applications - Screw-type for reliable contact

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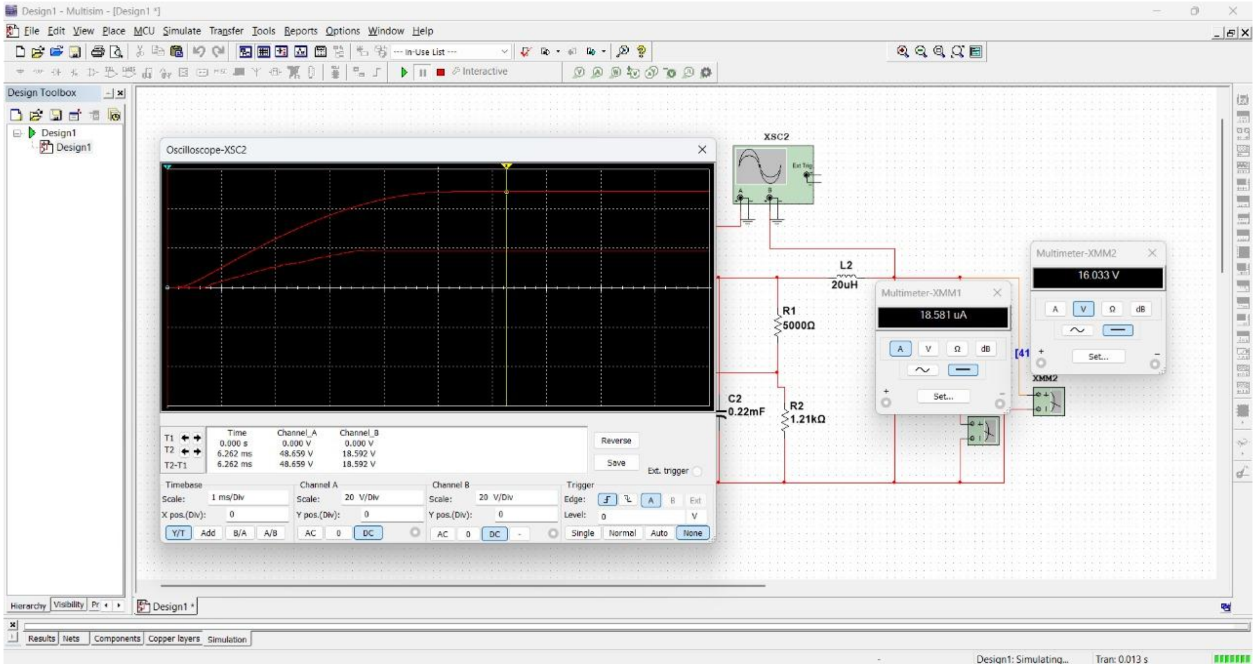
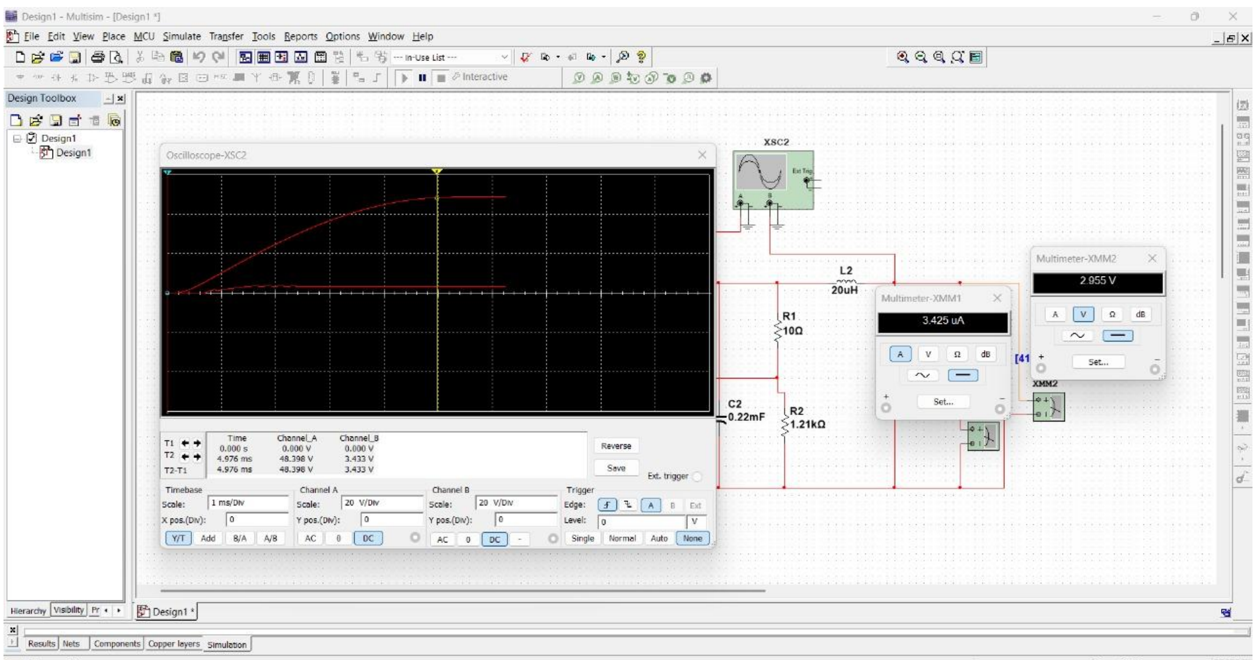
V. PERFORMANCE CHARACTERISTICS

A. Voltage Adjustment

R1 Value	Output Voltage	Output Current
5000Ω	19.2V	19.113µA
10Ω	3.39V	3.334µA





B. Key Performance Metrics -

Efficiency: Estimated 82–88% across load range
Ripple Voltage: <50mVpp with proper filtering
Load Regulation: <1% for 10–100% load changes
Line Regulation: <0.5% for input variations

VI. APPLICATIONS

Laboratory Power Supplies: Benchtop testing of various circuits
Industrial Control Systems: Powering sensors and controllers
Embedded Systems Development: Flexible voltage for prototyping
LED Driver Applications: Adjustable voltage for different LED arrays
Battery Charging Circuits: Customizable charging profiles

VII. MANUFACTURING READINESS

The design is production-ready with: - Complete Gerber files for PCB fabrication - Comprehensive BOM with manufacturer part numbers - Validated component footprints - Design rule checked layout

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VIII. CONCLUSION

This paper has presented a complete design flow for an adjustable buck converter power supply capable of handling 100V AC input and providing 3.3V to 20V adjustable output. The design demonstrates proper engineering practices from simulation through PCB layout, resulting in a manufacturable solution. The use of quality components like the Bourns potentiometer and Vishay inductors ensures reliable performance across the specified operating range.

Future enhancements could include: - Digital voltage control interface - Enhanced output current monitoring - Improved thermal management for high-current operation - Additional protection circuits

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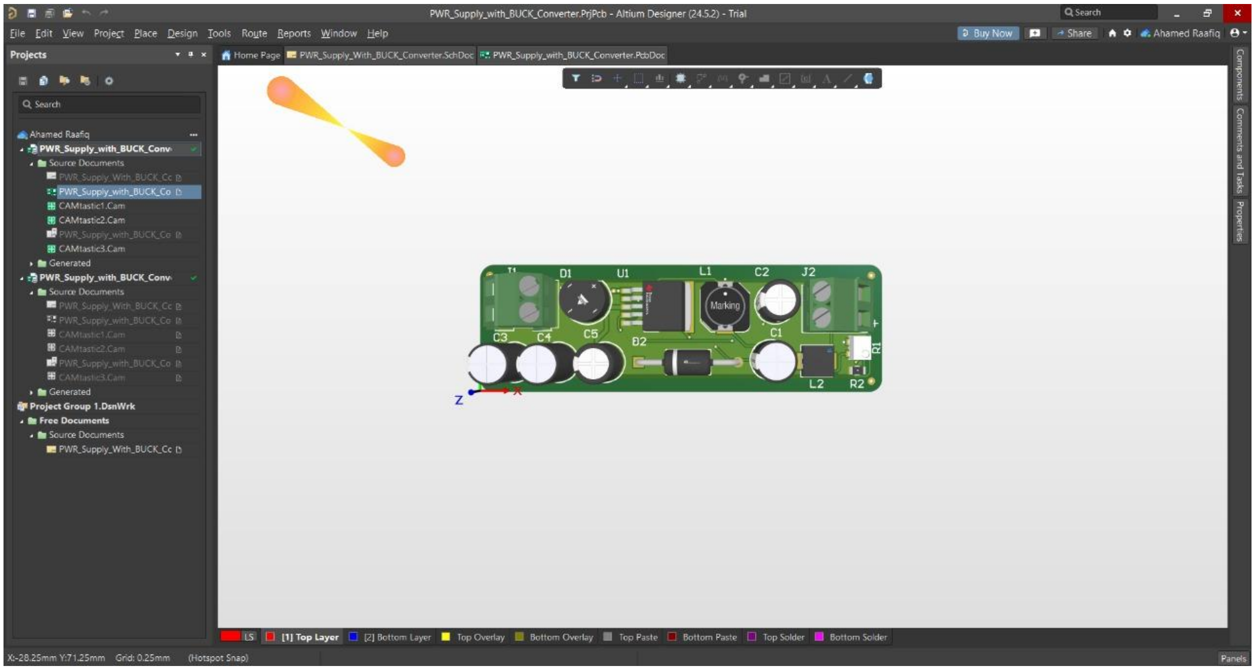
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